REMARKS

This Preliminary Amendment cancels original claims 1 to 12, and adds new claims 13 to 26 in the underlying PCT Application No. PCT/DE03/00464. The new claims conform the claims to the U.S. Patent and Trademark Office rules and do not add new matter to the application.

In accordance with 37 C.F.R. § 1.125, the Substitute Specification (including the Abstract, but without the claims) contains no new matter. The amendments reflected in the Substitute Specification (including the Title and Abstract) are to conform the Specification and Abstract to U.S. Patent and Trademark Office rules or to correct informalities. As required by 37 C.F.R. § 1.121 and § 1.125, a Marked Up Version Of The Substitute Specification comparing the Specification of record and the Substitute Specification also accompanies this Preliminary Amendment. In the Marked Up Version, underlining indicates added text and "strike-throughs" and double-brackets indicate deleted text. Approval and entry of the Substitute Specification (including Abstract) is respectfully requested.

The underlying PCT Application No. PCT/DE03/00464 includes an International Search Report, dated June 4, 2003, a copy of which is included. The Search Report includes a list of documents that were considered by the Examiner in the underlying PCT application.

It is asserted that the subject matter of the present application is new, non-obvious, and useful. ~~Prompt consideration~~ and allowance of the application are respectfully requested.

Respectfully Submitted,
KENYON & KENYON

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By: _____
Richard L. Mayer
Reg. No. 22,490

One Broadway
New York, New York 10004
Telephone: (212) 425-7200
Facsimile: (212) 425-5288

CUSTOMER NO. 26646

SENSOR ELEMENT

~~Background Information~~ FIELD OF INVENTION

The present invention ~~is based on a sensor element as generically defined by the preamble to the independent claim.~~ relates to a sensor element.

~~One such~~ BACKGROUND INFORMATION

A sensor element is ~~described~~ discussed for instance in German Published Patent ~~Disclosure DE~~ Application No. 199 37 163 ~~A1~~. The planar sensor element includes three ceramic substrate layers. On one~~,~~ measurement~~,~~ end of the sensor element, electrical elements, such as electrodes and a heating element, ~~are~~ may be disposed on and between the ceramic substrate layers. The electrical elements ~~are~~ may be electrically connected by conductor tracks to contact faces on an end toward the terminals of the sensor element. The contact faces ~~are~~ may be disposed on the outside of the sensor element and ~~are~~ may be in electrical contact with contact parts that make an electrical connection with an electrical wiring disposed outside the measuring sensor possible.

Both the electrical elements and the corresponding conductor tracks ~~are~~ may be disposed at least partially in a layer plane inside the sensor element. To make the electrical connection between the conductor track and the contact face ~~requires~~ may require throughplating through a ceramic substrate layer. Such throughplating ~~is~~ may be complicated from a production standpoint and ~~involves~~ may involve a not inconsiderable risk of error.

~~Summary of the Invention~~ SUMMARY OF THE INVENTION

~~The~~ A sensor element according to an exemplary embodiment of the present invention ~~having the characteristics of independent claim 1 has the advantage over the related art~~

~~that~~ may provide simple contacting of the sensor element in production terms ~~is achieved and may be accomplished~~ economically and with little risk of error. For that purpose, a contact face ~~is~~ may be disposed in a layer plane between a first and second layer of the sensor element, and in the region of the contact face, a recess ~~is~~ may be provided in the first ceramic layer.

An electrical element, such as an electrode or a heater, disposed inside the sensor element ~~is~~ may be connected electrically to the contact face via a conductor track. For contacting the sensor element, a contact part ~~is~~ may be disposed inside the recess in the first layer of the sensor element and ~~is~~ may in turn be electrically connected to an electrical wiring disposed outside the sensor element. The contact face and the conductor track ~~are~~ may be disposed in a layer plane of the sensor element, so that throughplating through a layer of the sensor element ~~is~~ may not ~~necessary~~ be required.

~~By the provisions recited in the dependent claims, advantageous refinements of the measuring sensor defined by the independent claim are possible.~~

The first and second layers ~~are advantageously embodied~~ may be provided as a ceramic substrate layer whose thickness is in the range from 0.05 mm to 1 mm. A substrate layer is understood hereinafter to be a layer that is suitable as a substrate for printed functional layers (such as an electrode, conductor track, heating element, or ceramic functional layers such as diffusion barriers, or porously filled gas chambers or insulation layers). Producing a sensor element containing such substrate layers ~~is~~ should be known to one skilled in the art and ~~will~~ therefore ~~be~~ sketched only briefly here. The functional layers ~~are~~ may be printed by screen printing on a so-called green sheet (a substrate layer in the unsintered state). The printed green sheets ~~are~~ may be laminated and then sintered. A substrate layer may also be an unprinted ceramic

layer having the above-described properties.

If the recess is shaped in slotlike form, then the contact part ~~is~~ may be securely connected electrically to the contact face, since the lateral walls of the slotlike recess may prevent lateral slippage of the contact part. If the slotlike recess is widened toward an outer face of the sensor element, it ~~becomes~~ may become simpler to slip the contact part onto the contact faces of the sensor element (self-centering).

In a sensor element which includes not only the first and second layers but also a further layer, which adjoins the first layer on the side of the first layer remote from the contact face, then the recess ~~is~~ may also be provided in the further layer, so that the contact part is also applied to the contact face laterally, that is, in a direction perpendicular to the plane of the contact face.

In ~~a preferred version~~ an exemplary embodiment of the present invention, the sensor element includes both the first and second layers and a third layer, the layer sequence being in the order given. Both in the layer plane between the first and second layers and in the layer plane between the second and third layers, the sensor element includes contact faces. Recesses ~~are~~ may be provided in the region of the contact faces in the first and third layers.

The electrical contact between the contact face and the contact part ~~is~~ may be made by a nonpositive and/or positive connection (for instance by soldering or welding, in particular by laser welding). The recess ~~is advantageously~~ may be made in the green sheet by of the first layer being stamped out, milled or drilled.

~~Brief Description of the Drawings~~

~~Exemplary embodiments of the present invention are shown in the drawing and described in further detail in the ensuing~~

~~description.~~

~~Figures 1, 2 and 3 show a perspective view of a portion of a sensor element of the invention, in a first, second and third version of a first exemplary embodiment;~~

~~Figure 4 is a longitudinal section through a portion of the sensor element taken along the line IV-IV in Figure 1; and~~

~~Figures 5 and 6 show a perspective view of a portion of a sensor element of the invention in a first and second version of a second exemplary embodiment.~~

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 shows a perspective view of a portion of a sensor element of a first version of a first exemplary embodiment of the present invention.

Figure 2 shows a perspective view of a portion of a sensor element of a second version of the first exemplary embodiment of the present invention.

Figure 3 shows a perspective view of a portion of a sensor element of a third version of the first exemplary embodiment of the present invention.

Figure 4 is a longitudinal section through a portion of the sensor element taken along the line IV-IV in Figure 1.

Figure 5 shows a perspective view of a portion of a sensor element of the present invention in a first version of a second exemplary embodiment.

Figure 6 shows a perspective view of a portion of a sensor element of the present invention in a second version of the second exemplary embodiment.

~~Description of the Preferred Embodiments~~ DETAILED DESCRIPTION

Figures 1 and 4, as a first version of a first exemplary embodiment of the present invention, show a terminal end of a sensor element 10. Sensor element 10 includes a first layer 21 and a second layer 22, which are embodied as ceramic substrate layers. In the layer plane between first and second layers 21, 22, two contact faces 30 as well as one conductor track 31 for each contact face 30 are disposed. Conductor track 31 makes an electrical connection between the contact face and an electrical element~~; the electrical element~~, which is provided on an end (not shown) of sensor element 10 on the measurement side, remote from the terminal end. First layer 21 forms an outer layer of sensor element 10, since no further substrate layer adjoins the side of first layer 21 remote from second layer 22.

First layer 21, in the region of contact faces 30, includes a recess 40 which extends over the entire width of sensor element 10. The first layer thus extends in the direction of the measurement end of sensor element 10, beginning at the transition from contact face 30 to conductor track 31.

For electrical insulation, a first and second insulation layer 35, 36 are disposed between the conductor track and the respective first and second layers 21, 22. Second insulation layer 36 also extends into the region of contact faces 30, so that contact faces 30 are insulated from second layer 22 by second insulation layer 36. Conversely, first insulation layer 36 is recessed in the region of contact faces 30.

In the other drawing figures the same reference numerals as in sensor element 10 shown in Figure 1 are used for corresponding elements in the further versions and exemplary embodiments of sensor element 10.

As a second version of the first exemplary embodiment of the present invention, Figure 2 shows a sensor element 10 which includes an additional third layer 23, which is likewise embodied as a ceramic substrate layer. Third layer 23 covers

second layer 22 completely on the side remote from first layer 21~~; that~~. That is, it has no recesses in the region of contact faces 30. Further contact faces may be disposed on the outside of third layer 23, that is, on the side of third layer 23 remote from second layer 22.

As a third version of the first exemplary embodiment of the present invention, Figure 3 shows a sensor element 10 which, like the second version, includes an additional third layer 23 that is likewise embodied as a ceramic substrate layer. Here, contact faces 30 are provided on second layer 22, both on the side toward first layer 21 and on the side toward third layer 23. In contrast to the second version, in the third version third layer 23 includes a further recess 41 in the region of contact faces 30.

As a first version of a second exemplary embodiment of the present invention, Figure 5 shows a sensor element 10, which differs from the sensor element shown in Figure 2 in that one recess 42 of slotlike shape is provided for each of the two contact faces 30. In the second version of the second exemplary embodiment shown in Figure 6, recesses 42 widen toward the outer face of sensor element 10 that is perpendicular to the longitudinal axis.

First, second and third ceramic layers 21, 22, 23 are substantially of zirconium oxide stabilized with yttrium. Both contact face 30 and conductor track 31 are substantially of platinum with a ceramic supporting framework. The first and second insulation layers contain aluminum oxide as their primary ingredient.

The present invention may also be adopted for other sensor elements, for instance with more than three substrate layers. The recesses may also be made laterally on the sensor element into one or more substrate layers. Moreover, it is possible to provide only one contact face, or more than two contact faces, with the corresponding recesses.

~~Abstract~~ ABSTRACT OF THE DISCLOSURE

A sensor element ~~(10)~~ constructed in layers for detecting a physical property of a gas or liquid, and in particular for detecting the concentration of a gas component or the temperature of an exhaust gas of an internal combustion engine. The sensor element ~~(10)~~ includes a first and second layer ~~(21, 22)~~ as well as at least one contact face~~(30)~~, which is disposed in a layer plane between the first and second layers~~(21, 22)~~. In the region of the contact face~~(30)~~, the first layer ~~(21)~~ includes a recess~~(40, 41, 42)~~.
~~(Figure 1)~~

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